

## CLAIMS

1        1. A computer implemented method for in-place  
2        preservation of file system objects during a clone  
3        operation, the method comprising the steps of:  
4                a cloning manager determining boundaries of a  
5                file system to be created by the clone  
6                operation;  
7                the cloning manager identifying at least one  
8                protected area within the boundaries  
9                reserved for the file system to be created  
10              by the clone operation;  
11              the cloning manager identifying at least one in-  
12              place file system object at least partially  
13              within the boundaries to be preserved during  
14              the clone operation;  
15              the cloning manager storing, in a location that  
16              will not be affected by the clone operation,  
17              metadata concerning each in-place file  
18              system object at least partially within the  
19              boundaries to be preserved during the clone  
20              operation;  
21              the cloning manager ensuring that each in-place  
22              file system object at least partially within

23                   the boundaries to be preserved during the  
24                   clone operation is not located in a  
25                   protected area; and  
26           the cloning manager creating the file system  
27                   during the clone operation only in locations  
28                   within the boundaries in which no in-place  
29                   file system object to be preserved is  
30                   located.

1           2. The method of claim 1 wherein the cloning manager  
2   determining the boundaries of a file system to be created  
3   by the clone operation comprises:  
4           the cloning manager analyzing data concerning the  
5                   clone operation to determine at least one  
6                   attribute concerning the file system to be  
7                   created from a group of attributes  
8                   consisting of:  
9                   a file system type of the file system to be  
10                   created;  
11                   a location of volume boundaries of the file  
12                   system to be created;  
13                   storage geometry concerning the file system  
14                   to be created; and

15                   a number of total sectors to be used by the  
16                   file system to be created.

1           3. The method of claim 1 wherein the cloning manager  
2     identifying at least one protected area within the  
3     boundaries reserved for the file system to be created by  
4     the clone operation comprises the cloning manager  
5     performing at least one step from a group of steps  
6     consisting of:

7                   identifying at least one protected area required  
8                   by the file system to be created by the  
9                   clone operation; and

10                  identifying at least one protected area not  
11                  required by but optimally reserved for the  
12                  file system to be created by the clone  
13                  operation.

1           4. The method of claim 1 wherein the cloning manager  
2     identifying at least one in-place file system object with  
3     the boundaries to be preserved during the clone operation  
4     comprises:

5                   the cloning manager compiling a list of in-place  
6                   file system objects to be preserved during  
7                   the clone operation; and

8           the cloning manager eliminating any in-place file  
9           system objects which will not be affected by  
10          the clone operation from the list.

1          5. The method of claim 4 wherein the cloning manager  
2          eliminating any in-place file system objects which will not  
3          be affected by the clone operation from the list further  
4          comprises:

5           the cloning manager identifying at least one file  
6           system object to be preserved which is not  
7           located on the physical medium on which the  
8           file system is to be created by the clone  
9           operation; and

10          the cloning manager eliminating each identified  
11          file system object which is not located on  
12          the physical medium from the list.

1          6. The method of claim 4 wherein the cloning manager  
2          eliminating any in-place file system objects which will not  
3          be affected by the clone operation from the list further  
4          comprises:

5           the cloning manager identifying at least one file  
6           system object to be preserved which is  
7           located outside of the boundaries of the

8 file system to be created by the clone  
9 operation; and  
10 the cloning manager eliminating each identified  
11 file system object which is located outside  
12 of the boundaries from the list.

1 7. The method of claim 1 wherein the cloning manager  
2 storing metadata concerning each in-place file system  
3 object to be preserved during the clone operation further  
4 comprises:

5 the cloning manager storing, for each in-place  
6 system object to be preserved during the  
7 clone operation, at least one metadatum  
8 concerning the file system object from a  
9 group of metadata consisting of:  
10 a path of the file system object;  
11 at least one attribute concerning the file  
12 system object; and  
13 a logical location of the file system  
14 object;  
15 a physical storage location of content of  
16 the file system object.

1 8. The method of claim 1 wherein the cloning manager  
2 storing metadata concerning each in-place file system

3 object to be preserved during the clone operation further  
4 comprises:  
5           the cloning manager storing the metadata in a  
6           location that will not be affected by the  
7           clone operation in a format from a group of  
8           formats consisting of:  
9           at least two files, each file containing the  
10           metadata so as to support fault  
11           tolerance;  
12           at least one record in a database supporting  
13           fault tolerance;  
14           a single file; and  
15           structured data in random access memory.

1       9. The method of claim 1 wherein the cloning manager  
2 ensuring that each in-place file system object at least  
3 partially within the boundaries to be preserved during the  
4 clone operation is not located in a protected area  
5 comprises:  
6       the cloning manager comparing a location of each  
7       file system object at least partially within  
8       the boundaries to be preserved during the  
9       clone operation to locations of identified

10                   protected areas reserved for the file system  
11                   to be created by the clone operation; and  
12       responsive to the cloning manager determining  
13                   that a location of a file system object  
14                   conflicts with a location of a protected  
15                   area, the cloning manager performing a step  
16                   from a group of steps consisting of:  
17       moving the conflicting file system object to  
18                   an available non-conflicting location,  
19                   and updating metadata concerning the  
20                   file system object accordingly; and  
21       classifying the result of the determination  
22                   as an error condition.

1       10. The method of claim 1 wherein the cloning manager  
2       creating the file system during the clone operation only in  
3       locations within the boundaries in which no in-place file  
4       system object to be preserved is located comprises:  
5       before allocating at least one sector for the  
6                   creation of the file system, the cloning  
7                   manager checking the stored metadata  
8                   concerning the in-place file system objects  
9                   to determine if at least one file system

10                   object to be preserved is located at that  
11                   location; and  
12       responsive to determining that at least one file  
13                   system object to be preserved is located at  
14                   that location, allocating the at least one  
15                   sector to the file system at an available  
16                   non-conflicting location.

1       11. The method of claim 1 wherein:  
2           the cloning manager identifying at least one in-  
3           place file system object at least partially  
4           within the boundaries to be preserved during  
5           the clone operation further comprises the  
6           cloning manager identifying at least one in-  
7           place file system object to be both  
8           preserved during the clone operation and  
9           incorporated into the file system created by  
10          the clone operation; and  
11       wherein the cloning manager storing, in a  
12           location that will not be affected by the  
13           clone operation, metadata concerning each  
14           in-place file system object further  
15           comprises the cloning manager storing  
16           metadata concerning each identified file



17 system object to be both preserved during  
18 the clone operation and incorporated into  
19 the file system created by the clone  
20 operation, the metadata comprising at least  
21 one metadatum from a group of metadata  
22 consisting of:  
23 an indication that the file system object is  
24 to be incorporated in the file system  
25 to be created by the clone operation;  
26 a recovery path of the file system object  
27 within the file system to be created by  
28 the clone operation; and  
29 a recovery partition of the file system  
30 object within the file system to be  
31 created by the clone operation.

1 12. The method of claim 11 further comprising:  
2 the cloning manager determining that at least one  
3 identified in-place file system object to be  
4 incorporated into the file system to be  
5 created by the clone operation is not  
6 compatible with the file system to be  
7 created by the clone operation; and

8 responsive to the determination, the cloning  
9 manager performing a step from a group of  
10 steps consisting of:  
11 modifying at least one identified file  
12 system object to be compatible with the  
13 file system to be created by the clone  
14 operation; and  
15 classifying the identification as an error  
16 condition.

1 13. The method of claim 11 further comprising:  
2 for each identified in-place file system object  
3 to be incorporated into the file system, the  
4 cloning manager determining whether its  
5 content is located within a location that is  
6 to be a data area of the file system, and  
7 whether its location is properly aligned  
8 according to storage geometry of the file  
9 system; and  
10 responsive to determining that the location of at  
11 least one in-place file system object to be  
12 incorporated into the file system is not  
13 compatible with the file system, the cloning

14           manager performing a step from a group of  
15           steps consisting of:  
16           moving the in-place file system object such  
17                 that its new location is compatible  
18                 with the file system and updating the  
19                 associated metadata accordingly; and  
20           classifying the result of the determination  
21                 as an error condition.

1           14. The method of claim 11 further comprising the  
2     cloning manager performing the following additional steps  
3     after the clone operation:  
4           using appropriate stored metadata to create a  
5                 directory entry in the created file system  
6                 for each identified file system object to be  
7                 incorporated into the created file system;  
8                 and  
9           updating metadata concerning the created file  
10                 system to map the content location of each  
11                 identified file system object into the  
12                 created file system.

1           15. The method of claim 1 further comprising:  
2                 the cloning manager determining whether target  
3                 storage medium is of sufficient size to

4           store each identified in-place file system  
5           object to be preserved during the clone  
6           operation and the file system to be created  
7           by the clone operation;  
8       responsive to the result of the determining step,  
9           the cloning manager performing a step from a  
10          group of steps consisting of:  
11       responsive to determining that the target  
12           storage medium is of sufficient size,  
13           proceeding with the clone operation;  
14           and  
15       responsive to determining that the target storage  
16          medium is not of sufficient size,  
17          classifying the result of the determination  
18          as an error condition.

1       16. The method of claim 1 further comprising:  
2           the cloning manager creating at least two file  
3           systems during the clone operation.

      17. The method of claim 1 further comprising:  
5           the cloning manager creating at least one file system  
      during the clone operation on at least two storage media.

1        18. A computer readable medium containing a computer  
2 program product for in-place preservation of file system  
3 objects during a clone operation, the computer program  
4 product comprising:  
5            program code for determining boundaries of a file  
6                    system to be created by the clone operation;  
7            program code for identifying at least one  
8                    protected area within the boundaries  
9                    reserved for the file system to be created  
10                  by the clone operation;  
11           program code for identifying at least one in-  
12                   place file system object at least partially  
13                   within the boundaries to be preserved during  
14                   the clone operation;  
15           program code for storing, in a location that will  
16                   not be affected by the clone operation,  
17                   metadata concerning each in-place file  
18                   system object at least partially within the  
19                   boundaries to be preserved during the clone  
20                   operation;  
21           program code for ensuring that each in-place file  
22                   system object at least partially within the  
23                   boundaries to be preserved during the clone

24                   operation is not located in a protected  
25                   area; and  
26           program code for creating the file system during  
27           the clone operation only in locations within  
28           the boundaries in which no in-place file  
29           system object to be preserved is located.

1           19. The computer program product of 18 wherein the  
2   program code for determining the boundaries of a file  
3   system to be created by the clone operation comprises:  
4           program code for analyzing data concerning the  
5           clone operation to determine at least one  
6           attribute concerning the file system to be  
7           created from a group of attributes  
8           consisting of:  
9           a file system type of the file system to be  
10           created;  
11           a location of volume boundaries of the file  
12           system to be created;  
13           storage geometry concerning the file system  
14           to be created; and  
15           a number of total sectors to be used by the  
16           file system to be created.

1        20. The computer program product of claim 18 wherein  
2 the program code for identifying at least one protected  
3 area within the boundaries reserved for the file system to  
4 be created by the clone operation further comprises at  
5 least one program code from a group of program codes  
6 consisting of:

7            program code for identifying at least one  
8            protected area required by the file system  
9            to be created by the clone operation; and  
10          program code for identifying at least one  
11          protected area not required by but optimally  
12          reserved for the file system to be created  
13          by the clone operation.

1        21. The computer program product of claim 18 wherein  
2 the program code for storing metadata concerning each in-  
3 place file system object to be preserved during the clone  
4 operation further comprises:

5            program code for storing, for each in-place  
6            system object to be preserved during the  
7            clone operation, at least one metadatum  
8            concerning the file system object from a  
9            group of metadata consisting of:  
10          a path of the file system object;

11           at least one attribute concerning the file  
12           system object; and  
13           a logical location of the file system  
14           object;  
15           a physical storage location of content of  
16           the file system object.

1       22. The computer program product of claim 18 wherein  
2 the program code for storing metadata concerning each in-  
3 place file system object to be preserved during the clone  
4 operation further comprises:  
5       program code for storing the metadata in a  
6       location that will not be affected by the  
7       clone operation in a format from a group of  
8       formats consisting of:  
9       at least two files, each file containing the  
10       metadata so as to support fault  
11       tolerance;  
12       at least one record in a database supporting  
13       fault tolerance;  
14       a single file; and  
15       structured data in random access memory.

1       23. The computer program product of claim 18 wherein  
2 the program code for ensuring that each in-place file



3 system object at least partially within the boundaries to  
4 be preserved during the clone operation is not located in a  
5 protected area comprises:

6 program code for comparing a location of each  
7 file system object at least partially within  
8 the boundaries to be preserved during the  
9 clone operation to locations of identified  
10 protected areas reserved for the file system  
11 to be created by the clone operation; and

12 at least one program code for from a group of  
13 program codes consisting of:

14 program code for, responsive to determining  
15 that a location of a file system object  
16 conflicts with a location of a  
17 protected area, moving the conflicting  
18 file system object to an available non-  
19 conflicting location, and updating  
20 metadata concerning the file system  
21 object accordingly; and

22 program code for, responsive to determining  
23 that a location of a file system object  
24 conflicts with a location of a  
25 protected area, classifying the result

26                               of the determination as an error  
27                               condition.

1           24. The computer program product of claim 18 wherein  
2 the program code for creating the file system during the  
3 clone operation only in locations within the boundaries in  
4 which no in-place file system object to be preserved is  
5 located comprises:

6               program code for, before allocating at least one  
7               sector for the creation of the file system,  
8               checking the stored metadata concerning the  
9               in-place file system objects to determine if  
10              at least one file system object to be  
11              preserved is located at that location; and  
12              program code for, responsive to determining that  
13              at least one file system object to be  
14              preserved is located at that location,  
15              allocating the at least one sector to the  
16              file system at an available non-conflicting  
17              location.

1           25. The computer program product of claim 18 wherein:  
2              the program code for identifying at least one in-  
3              place file system object at least partially  
4              within the boundaries to be preserved during

5           the clone operation further comprises  
6           program code for identifying at least one  
7           in-place file system object to be both  
8           preserved during the clone operation and  
9           incorporated into the file system created by  
10          the clone operation; and  
11         wherein the program code for storing, in a  
12           location that will not be affected by the  
13           clone operation, metadata concerning each  
14           in-place file system object further  
15           comprises program code for storing metadata  
16           concerning each identified file system  
17           object to be both preserved during the clone  
18           operation and incorporated into the file  
19           system created by the clone operation, the  
20           metadata comprising at least one metadatum  
21           from a group of metadata consisting of:  
22           an indication that the file system object is  
23                 to be incorporated in the file system  
24                 to be created by the clone operation;  
25           a recovery path of the file system object  
26                 within the file system to be created by  
27                 the clone operation; and

28                   a recovery partition of the file system  
29                   object within the file system to be  
30                   created by the clone operation.

1       26. The computer program product of claim 25 further  
2 comprising:  
3       program code for determining, for each identified  
4       in-place file system object to be  
5       incorporated into the file system, whether  
6       its content is located within a location  
7       that is to be a data area of the file  
8       system, and whether its location is properly  
9       aligned according to storage geometry of the  
10      file system; and  
11      at least one program code from a group of program  
12      codes consisting of:  
13      program code for, responsive to determining  
14      that the location of at least one in-  
15      place file system object to be  
16      incorporated into the file system is  
17      not compatible with the file system,  
18      moving the in-place file system object  
19      such that its new location is  
20      compatible with the file system and

21                   updating the associated metadata  
22                   accordingly; and  
23           program code for, responsive to determining  
24           that the location of at least one in-  
25           place file system object to be  
26           incorporated into the file system is  
27           not compatible with the file system,  
28           classifying the result of the  
29           determination as an error condition.

1       27. The computer program product of claim 25 further  
2 comprising:  
3           program code for using appropriate stored  
4           metadata to create a directory entry in the  
5           created file system for each identified file  
6           system object to be incorporated into the  
7           created file system; and  
8           program code for updating metadata concerning the  
9           created file system to map the content  
10          location of each identified file system  
11          object into the created file system.

1       28. A computer system for in-place preservation of  
2 file system objects during a clone operation, the computer  
3 system comprising:

4           a software portion configured to determine  
5           boundaries of a file system to be created by  
6           the clone operation;  
7           a software portion configured to identify at  
8           least one protected area within the  
9           boundaries reserved for the file system to  
10          be created by the clone operation;  
11          a software portion configured to identify at  
12          least one in-place file system object at  
13          least partially within the boundaries to be  
14          preserved during the clone operation;  
15          a software portion configured to store, in a  
16          location that will not be affected by the  
17          clone operation, metadata concerning each  
18          in-place file system object at least  
19          partially within the boundaries to be  
20          preserved during the clone operation;  
21          a software portion configured to ensure that each  
22          in-place file system object at least  
23          partially within the boundaries to be  
24          preserved during the clone operation is not  
25          located in a protected area; and  
26          a software portion configured to create the file  
27          system during the clone operation only in

28                locations within the boundaries in which no  
29                in-place file system object to be preserved  
30                is located.

1            29. The computer system of 28 wherein the software  
2            portion configured to determine the boundaries of a file  
3            system to be created by the clone operation comprises:  
4                a software portion configured to analyze data  
5                concerning the clone operation to determine  
6                at least one attribute concerning the file  
7                system to be created from a group of  
8                attributes consisting of:  
9                a file system type of the file system to be  
10                created;  
11                a location of volume boundaries of the file  
12                system to be created;  
13                storage geometry concerning the file system  
14                to be created; and  
15                a number of total sectors to be used by the  
16                file system to be created.

1            30. The computer system of claim 28 wherein the  
2            software portion configured to identify at least one  
3            protected area within the boundaries reserved for the file  
4            system to be created by the clone operation further

comprises at least one software portion from group of  
software portions consisting of:

a software portion configured to identify at  
least one protected area required by the  
file system to be created by the clone  
operation; and

a software portion configured to identify at  
least one protected area not required by but  
optimally reserved for the file system to be  
created by the clone operation.

31. The computer system of claim 28 wherein the  
software portion configured to store metadata concerning  
each in-place file system object to be preserved during the  
clone operation further comprises:

a software portion configured to store, for each  
in-place system object to be preserved  
during the clone operation, at least one  
metadatum concerning the file system object  
from a group of metadata consisting of:  
a path of the file system object;  
at least one attribute concerning the file  
system object; and



13                   a logical location of the file system  
14                   object;  
15                   a physical storage location of content of  
16                   the file system object.

1           32. The computer system of claim 28 wherein the  
2 software portion configured to store metadata concerning  
3 each in-place file system object to be preserved during the  
4 clone operation further comprises:

5                   a software portion configured to store the  
6                   metadata in a location that will not be  
7                   affected by the clone operation in a format  
8                   from a group of formats consisting of:  
9                   at least two files, each file containing the  
10                   metadata so as to support fault  
11                   tolerance;  
12                   at least one record in a database supporting  
13                   fault tolerance;  
14                   a single file; and  
15                   structured data in random access memory.

1           33. The computer system of claim 28 wherein the  
2 software portion configured to ensure that each in-place  
3 file system object at least partially within the boundaries

4 to be preserved during the clone operation is not located  
5 in a protected area comprises:

6 a software portion configured to compare a  
7 location of each file system object at least  
8 partially within the boundaries to be  
9 preserved during the clone operation to  
10 locations of identified protected areas  
11 reserved for the file system to be created  
12 by the clone operation; and

13 at least one software portion from a group of  
14 software portions consisting of:

15 a software portion configured to move,  
16 responsive to determining that a  
17 location of a file system object  
18 conflicts with a location of a  
19 protected area, the conflicting file  
20 system object to an available non-  
21 conflicting location, and to update  
22 metadata concerning the file system  
23 object accordingly; and

24 a software portion configured to classify,  
25 responsive to determining that a  
26 location of a file system object  
27 conflicts with a location of a

28                   protected area, the result of the  
29                   determination as an error condition.

1       34. The computer system of claim 28 wherein the  
2       software portion configured to create the file system  
3       during the clone operation only in locations within the  
4       boundaries in which no in-place file system object to be  
5       preserved is located comprises:  
6               a software portion configured to check, before  
7               allocating at least one sector for the  
8               creation of the file system, the stored  
9               metadata concerning the in-place file system  
10              objects to determine if at least one file  
11              system object to be preserved is located at  
12              that location; and  
13              a software portion configured to allocate,  
14              responsive to determining that at least one  
15              file system object to be preserved is  
16              located at that location, the at least one  
17              sector to the file system at an available  
18              non-conflicting location.

1       35. The computer system of claim 28 wherein:  
2               the software portion configured to identify at  
3               least one in-place file system object at

4           least partially within the boundaries to be  
5           preserved during the clone operation further  
6           comprises a software portion configured to  
7           identify at least one in-place file system  
8           object to be both preserved during the clone  
9           operation and incorporated into the file  
10          system created by the clone operation; and  
11          wherein the software portion configured to store,  
12          in a location that will not be affected by  
13          the clone operation, metadata concerning  
14          each in-place file system object further  
15          comprises a software portion configured to  
16          store metadata concerning each identified  
17          file system object to be both preserved  
18          during the clone operation and incorporated  
19          into the file system created by the clone  
20          operation, the metadata comprising at least  
21          one metadatum from a group of metadata  
22          consisting of:  
23          an indication that the file system object is  
24                  to be incorporated in the file system  
25                  to be created by the clone operation;

26 a recovery path of the file system object  
27 within the file system to be created by  
28 the clone operation; and  
29 a recovery partition of the file system  
30 object within the file system to be  
31 created by the clone operation.

1 36. The computer system of claim 35 further  
2 comprising:

3 a software portion configured to determine, for  
4 each identified in-place file system object  
5 to be incorporated into the file system,  
6 whether its content is located within a  
7 location that is to be a data area of the  
8 file system, and whether its location is  
9 properly aligned according to storage  
10 geometry of the file system; and

11 at least one software portion from a group of  
12 software portions consisting of:

13 a software portion configured to move,  
14 responsive to determining that the  
15 location of at least one in-place file  
16 system object to be incorporated into  
17 the file system is not compatible with

18 the file system, the in-place file  
19 system object such that its new  
20 location is compatible with the file  
21 system and updating the associated  
22 metadata accordingly; and  
23 a software portion configured to classify,  
24 responsive to determining that the  
25 location of at least one in-place file  
26 system object to be incorporated into  
27 the file system is not compatible with  
28 the file system, the result of the  
29 determination as an error condition.

1 37. The computer system of claim 35 further  
2 comprising:  
3 a software portion configured to use appropriate  
4 stored metadata to create a directory entry  
5 in the created file system for each  
6 identified file system object to be  
7 incorporated into the created file system;  
8 and  
9 a software portion configured to update metadata  
10 concerning the created file system to map

11 the content location of each identified file  
12 system object into the created file system.